Java CyclicBarrier: Example Application

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Learning Objectives in this Part of the Lesson

- Understand the structure & functionality of Java CyclicBarrier
- Recognize the key methods in the Java CyclicBarrier
- Know how to program with Java CyclicBarrier in practice

```java
class GCDCyclicBarrierWorker implements Runnable {
    private final CyclicBarrier mEntryBarrier;
    private final CyclicBarrier mExitBarrier; ...

    GCDCyclicBarrierWorker(CyclicBarrier entryBarrier,
                             CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExit Barrier.await();
        ...
    }
}
```
Overview of the GCD App
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• This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms.

See github.com/douglasraigschmidt/POSA/tree/master/ex/M3/GCD/CyclicBarrier
Overview of the GCD App

• This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms
• GCD computes the largest positive integer that is a divisor of two numbers
  • e.g., the GCD of 80 & 120 = 40

See en.wikipedia.org/wiki/Greatest_common_divisor
Overview of the GCD App

- This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms
  - GCD computes the largest positive integer that is a divisor of two numbers
  - Four GCD algorithms are tested
Overview of the GCD App

• This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms
  • GCD computes the largest positive integer that is a divisor of two numbers
  • Four GCD algorithms are tested
    • The gcd() method defined by BigInteger

See [docs.oracle.com/javase/8/docs/api/java/math/BigInteger.html#gcd](https://docs.oracle.com/javase/8/docs/api/java/math/BigInteger.html#gcd)
This Android app uses CyclicBarrier objects to coordinate the concurrent benchmarking of four Greatest Common Divisor (GCD) algorithms.

- GCD computes the largest positive integer that is a divisor of two numbers.
- Four GCD algorithms are tested:
  - The gcd() method defined by BigInteger
  - An iterative Euclid algorithm

See [en.wikipedia.org/wiki/Euclidean_algorithm](en.wikipedia.org/wiki/Euclidean_algorithm)
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    - An iterative Euclid algorithm
    - A recursive Euclid algorithm
    - A complex GCD algorithm that uses binary arithmetic

See [en.wikipedia.org/wiki/Binary_GCD_algorithm](en.wikipedia.org/wiki/Binary_GCD_algorithm)
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  • An iterative Euclid algorithm
  • A recursive Euclid algorithm
  • A complex GCD algorithm that uses binary arithmetic

However, the details of these algorithms are not important for our discussion.
GCDCyclicBarrierTest
Class Walkthrough
Create worker threads that use exit & entry barrier CyclicBarrier objects

class GCDCyclicBarrierTest {
    @Test public void testGCDCyclicBarrierTester() {
        List<GCDTuple> gcdTests = makeGCDTuples();

        CyclicBarrier entryBarrier =
            new CyclicBarrier(gcdTests.size() + 1, () ->
                GCDCyclicBarrierWorker.initializeInput(sITERATIONS));

        CyclicBarrier exitBarrier =
            new CyclicBarrier(gcdTests.size() + 1);

        for (int cycle = 1; cycle <= sCYCLES; cycle++) {
            gcdTests.forEach(gcdTuple -> new Thread(new
                                    GCDCyclicBarrierWorker(entryBarrier, exitBarrier,
                                                        gcdTuple, this)).start());
        }

        System.out.println("Starting tests");
        entryBarrier.await();
        System.out.println("Waiting for results");
        exitBarrier.await();
        System.out.println("All tests done"); ...

See GCD/CyclicBarrier/app/src/test/java/edu/vandy/gcdtesttask/GCDCyclicBarrierTest.java
GCDCyclicBarrierTest Class Walkthrough

- Create worker threads that use exit & entry barrier CyclicBarrier objects

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```

Entry point into the unit test
GCDCyclicBarrierTest Class Walkthrough

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• Create worker threads that use exit & entry barrier CyclicBarrier objects

We add a "+ 1" for the thread that initializes the tests
GCDCyclicBarrierTest Class Walkthrough

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            System.out.println("Starting tests");
            entryBarrier.await();
            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done");
        }
    }
}
```

Barrier action allocates each cycle’s input
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            System.out.println("Starting tests");
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            new CyclicBarrier(gcdTests.size() + 1);

        for (int cycle = 1; cycle <= sCYCLES; cycle++) {
            gcdTests.forEach(gcdTuple ->
                new Thread(new GCDCyclicBarrierWorker(entryBarrier, exitBarrier, 
                    gcdTuple, this)).start());
            System.out.println("Starting tests"); // Don't start just yet
            entryBarrier.await();
            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done"); ...
        }
    }
}
```
GCDCyclicBarrierTest Class Walkthrough

- Create worker threads that use exit & entry barrier CyclicBarrier objects

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            System.out.println("Starting tests");
            entryBarrier.await();
            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done");
        }
    }
}
```

Let all worker threads proceed at the same time, fixing limitation with CountDownLatch

See previous lesson on “Java CountDownLatch”
GCDCyclicBarrierTest Class Walkthrough

- Create worker threads that use exit & entry barrier CyclicBarrier objects

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            System.out.println("Starting tests");
            entryBarrier.await();
            System.out.println("Waiting for results");
            exitBarrier.await();
            System.out.println("All tests done");
        }
    }
}
```

After `await()` returns for a CyclicBarrier it will be reset (& is thus reusable) without needing to create a new CyclicBarrier instance.
GCDCyclicBarrierWorker Class Walkthrough
class GCDCyclicBarrierWorker implements Runnable {
  private final CyclicBarrier mEntryBarrier;
  private final CyclicBarrier mExitBarrier;
  ...

  GCDCyclicBarrierWorker(CyclicBarrier entryBarrier, 
                         CyclicBarrier exitBarrier, ...) {
    mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
    ...
  }

  public void run() {
    ...
    mEntryBarrier.await();
    runTest();
    mExitBarrier.await();
    ...
  }

• This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

See GCD/CyclicBarrier/app/src/main/java/edu/vandy/gcdtesttask/presenter/GCDCyclicBarrierWorker.java
GCDCyclicBarrierWorker Class Walkthrough

• This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

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    GCDCyclicBarrierWorker(CyclicBarrier entryBarrier,
                          CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();
        ...
    }
}
GCDCyclicBarrierWorker Class Walkthrough

• This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

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                            CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
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    }

    public void run() {
        ...
        mEntryBarrier.await();
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GCDCyclicBarrierWorker Class Walkthrough

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    GCDCyclicBarrierWorker(CyclicBarrier entryBarrier,
                           CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();
        ...
    }
```

This entry barrier causes all worker threads to wait until they are all ready, thus fixing the earlier limitation with CountDownLatch

See previous lesson on "Java CountDownLatch"
GCDCyclicBarrierWorker Class Walkthrough

- This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

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    private final CyclicBarrier mEntryBarrier;
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    GCDCyclicBarrierWorker(CyclicBarrier entryBarrier,
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        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();  Run the GCD algorithm associated with this object
        mExitBarrier.await();
        ...
    }
}
GCDCyclicBarrierWorker Class Walkthrough

- This class applies two entry & exit barrier CyclicBarrier objects to coordinate the benchmarking of a given GCD algorithm implementation

```java
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    ...  

    GCDCyclicBarrierWorker(CyclicBarrier entryBarrier,
                           CyclicBarrier exitBarrier, ...) {
        mEntryBarrier = entryBarrier; mExitBarrier = exitBarrier;
        ...
    }

    public void run() {
        ...
        mEntryBarrier.await();
        runTest();
        mExitBarrier.await();  // Exit barrier waits until all threads are done before returning
        ...
    }
}
```
End of Java CyclicBarrier: Example Application